

CLAIMS

What is claimed is:

1. A semiconductor package comprising:
 - a low-K Si die having front and back surfaces, the low-K Si die including a
 - 5 plurality of layers of low-K material;
 - a packaging substrate having die and board surfaces;
 - a heat spreader;
 - a thermal interface material coupling the heat spreader to the back surface of
 - the low-K Si die, the thermal interface material having a thermal interface material
 - 10 modulus that is higher than or equal to 100 MPa; and
 - an adhesive coupling the heat spreader to the die surface of the packaging
 - substrate, the adhesive having an adhesive modulus that is lower than or equal to 10
 - MPa.
- 15 2. A semiconductor package as recited in claim 1, wherein the low-K Si die is
- stably integrated within the semiconductor package such that the reliability of the low-
- K Si die is not substantially impaired by internal stress of the semiconductor package,
- the internal stress being created from cycling the temperature of the semiconductor
- package from -55 °C to 125 °C.
- 20 3. A semiconductor package as recited in claim 1, wherein the low-K Si die is
- an extra low-K Si die including a plurality of layers of extra low-K material.
4. A semiconductor package as recited in claim 1, wherein the layer of low-K
- 25 material has a thickness of 6 microns or less.
5. A semiconductor package as recited in claim 1, wherein the low-K Si die
- has a thickness in the range of 19 mil to 28 mil.
- 30 6. A semiconductor package as recited in claim 1, wherein the low-K Si die
- size ranges from 2 mm x 2 mm to 30 mm x 30 mm.

7. A semiconductor package as recited in claim 1, wherein the packaging substrate size ranges up to 45 mm x 45 mm.

5 8. A semiconductor package as recited in claim 1, wherein the thermal interface material is has a modulus about 400 MPa.

9. A semiconductor package as recited in claim 1, wherein the adhesive has a modulus about 4 MPa.

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10. A semiconductor package as recited in claim 1, wherein the front surface of the low-K Si die is electrically and mechanically coupled with the die surface of the packaging substrate.

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11. A semiconductor package as recited in claim 10, wherein the low-K Si die includes a plurality of solder bumps on the front surface of the low-K Si die for electrically and mechanically coupling the front surface of the low-K Si die with the die surface of the packaging substrate.

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12. A semiconductor package as recited in claim 11, wherein the plurality of solder bumps offset the low-K Si die from the packaging substrate such that a gap is formed in between the front surface of the low-K Si die and the die surface of the packaging substrate.

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13. A semiconductor package as recited in claim 12, wherein the gap is filled with an underfill material.

14. A method of forming a semiconductor package comprising:

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providing a low-K Si die having front and back surfaces and a packaging substrate having die and board surfaces, the low-K Si die including a plurality of layers of low-K material;

connecting a heat spreader to the back surface of the low-K Si die with a thermal interface material having a modulus that is higher than or equal to 100 MPa; and

5 connecting the heat spreader to the die surface of the packaging substrate with an adhesive having a modulus that is lower than or equal to 10 MPa.

15. A method of forming a semiconductor package as recited in claim 14, further comprising:

10 cycling the temperature of the semiconductor package from -55 °C to 125 °C to create internal stress within the semiconductor package, wherein the low-K Si die is stably integrated within the semiconductor package such that the reliability of the low-K Si die is not substantially impaired by the internal stress of the semiconductor package.

15 16. A method of forming a semiconductor package as recited in claim 14, wherein the low-K Si die is an extra low-K Si die including a plurality of layers of extra low-K material.

20 17. A method of forming a semiconductor package as recited in claim 14, wherein the layer of low-K material has a thickness of 6 microns or less.

18. A method of forming a semiconductor package as recited in claim 14, wherein the low-K Si die has a thickness in the range of 19 mil to 28 mil.

25 19. A method of forming a semiconductor package as recited in claim 14, wherein the low-K Si die size ranges from 2 mm x 2 mm to 30 mm x 30 mm.

30 20. A method of forming a semiconductor package as recited in claim 14, wherein the packaging substrate size ranges up to 45 mm x 45 mm.

21. A method of forming a semiconductor package as recited in claim 14, wherein the thermal interface material is has a modulus about 400 MPa.

22. A method of forming a semiconductor package as recited in claim 14, wherein the adhesive has a modulus about 4 MPa.

5 23. A method of forming a semiconductor package as recited in claim 14, further comprising:

 electrically and mechanically coupling the front surface of the low-K Si die with the die surface of the packaging substrate.

10 24. A method of forming a semiconductor package as recited in claim 23, wherein the low-K Si die includes a plurality of solder bumps on the front surface of the low-K Si die for electrically and mechanically coupling the front surface of the low-K Si die with the die surface of the packaging substrate.

15 25. A method of forming a semiconductor package as recited in claim 24, wherein the plurality of solder bumps offset the low-K Si die from the packaging substrate such that a gap is formed in between the front surface of the low-K Si die and the die surface of the packaging substrate.

20 26. A semiconductor package, comprising:
 a low-K Si die having front and back surfaces and a packaging substrate having die and board surfaces, the low-K Si die including a plurality of layers of low-K material;

 means for electrically and mechanically coupling the front surface of the low-K Si die with the die surface of the packaging substrate;

25 means for connecting a heat spreader to the back surface of the low-K Si die with a thermal interface material having a modulus that is higher than or equal to 100 MPa; and

 means for connecting the heat spreader to the die surface of the packaging
30 substrate with an adhesive having a modulus that is lower than or equal to 10 MPa.